

*THE ROLE OF PHYSICAL IDENTITY OF THE SAMPLE  
AND CORRECT COMPARISON STIMULUS IN  
MATCHING-TO-SAMPLE PARADIGMS<sup>1</sup>*

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Pigeons were trained in a higher-order conditional discrimination paradigm to assess the role of physical identity in a within-subjects design. A line orientation which was superimposed on all response keys signalled whether a response to the matching color or a response to the nonmatching color was correct. Following training under this paradigm, stimulus control gradients were obtained by varying the angularity of the lines. Orderly gradients of stimulus control were obtained and no bias toward or away from the physically identical comparison stimulus was observed. The data were interpreted as indicating that the pigeons acquired a discrimination for each specific stimulus configuration or a set of specific stimulus-response chains based on compound stimuli in which physical identity played no special role.

*Key words:* matching-to-sample, oddity-from-sample, conditional discriminations, compound stimuli, generalization gradients, stimulus control, key peck, pigeons

Under a matching-to-sample paradigm, the correct response is the selection of the comparison stimulus that is identical to the sample stimulus. The physical identity of the sample and correct comparison stimulus apparently has no special status for pigeons. This has been established by comparisons of matching-to-sample and symbolic matching-to-sample performances (Carter and Eckerman, 1975; Cohen, Looney, Brady, and Aucella, 1976). In symbolic matching-to-sample, the sample stimulus bears an arbitrary relation to comparison stimuli, since they are on different dimensions (*e.g.*, colored samples *versus* line comparisons). Carter and Eckerman (1975) have shown that the acquisition of line-line matching takes 4.5 times longer than the acquisition of hue-line matching (where the first term designates the sample stimulus dimension and the second term the comparison dimension). Since these tasks differed only with respect to the discriminability of samples, and since a simple

successive discrimination between lines took 4.5 times longer to acquire than the same task with hues, they concluded that rates of acquisition for hue-line and line-line matching differed as a function of the discriminability of one sample from another, and that identity between sample and comparison stimuli plays no role for pigeons. Cohen *et al.* (1976) found no differences in the rates and patterns of acquisition of both matching and symbolic matching when pigeons were pretrained on a successive discrimination with the two stimuli that were to be used as samples.

The role of physical identity can also be assessed by comparing matching-to-sample performance with oddity-from-sample performance. In an oddity discrimination, the correct response is the selection of the comparison stimulus that is different from the sample. In the present research, a higher-order conditional discrimination paradigm was employed to make direct comparisons of matching and oddity performance within subjects. Under this paradigm, a line orientation was superimposed on all of the response keys to signal whether a response to the matching color or a response to the nonmatching color was correct. Following training under this paradigm, stimulus-control gradients were obtained by varying the angularity of the lines. It should be noted that in this paper, the terms matching and oddity are used to refer to the experiment-

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ers' rule for reinforcement within these paradigms, rather than the nature of stimulus control that develops.

## METHOD

### *Subjects*

Six White Carneaux pigeons, with unrestricted access to water and grit in their home cages, were maintained at 80% of their free-feeding weights throughout the experiment. Before the present experiment, all subjects had received higher-order conditional discrimination training for 80 to 90 sessions, as well as transfer testing in which the same line orientations signalled matching or oddity trials but blue and yellow hues were substituted for the original red and green training hues (*cf.* Santi, 1976).

### *Apparatus*

Four Lehigh Valley pigeon chambers Model #1519 were used; each was enclosed in a plywood box insulated with acoustical ceiling tile. Masking noise and ventilation were provided by two 100-CFM Dayton blowers located on the left side wall and back wall, respectively, of each apparatus and holding box. The three translucent (Perspex) response keys were all 2.54 cm in diameter. The stimuli used (red, green, yellow, or blue and a white line with an orientation of 0°, 22.5°, 45°, 67.5°, or 90° from horizontal) could be projected on the reverse side of the translucent key by an In-Line Digital Unit. Directly below this key was a 5.08-cm square opening that provided occasional access to a hopper filled with mixed grain. General illumination was provided by a houselight located above the center response key. All experimental dependencies and response measures were arranged and recorded by a PDP-8I digital computer located in a separate room.

### *Procedure*

*Intermittent reinforcement.* During this phase, red or green lights were presented with a line tilt of 0° or 90° superimposed on them. One of the side keys was illuminated with a color the same as that on the center key; the other side key was illuminated with a color different from that on the center key. The line orientation that was superimposed on all response keys signalled whether a response to

the matching color or a response to the non-matching color was correct. For three of the birds (P1, P5, and P7), the 0° line was correlated with reinforcement for responding to the color that matched that on the center key, while the 90° line was correlated with reinforcement for responding to the color that mismatched that on the center key. For the remaining three birds, (P4, P6, and P8) this relationship was reversed. Since the red and green stimuli were counterbalanced over the left and right keys and the superimposed line tilt was 0° or 90°, eight different stimulus configurations resulted.

Sessions consisted of 288 trials (36 randomized blocks of the eight different stimulus combinations). A trial commenced with the illumination of the center key by a line tilt superimposed on a colored background. A response on this key resulted in the presentation of the appropriate comparison stimuli on both of the side keys. One of every four trials was randomly selected as a reinforcement trial. On reinforcement trials, a response to the correct comparison was followed by a 3-sec access to mixed grain; a response to the incorrect comparison was followed by a 3-sec blackout. Following either reinforcement or blackout, an intertrial interval of 15 sec occurred, during which only the houselight was illuminated. On trials for which no reinforcement was available, a response to the side key was followed immediately by the intertrial interval. Intermittent reinforcement was continued for 10 sessions before stimulus-control testing.

### *Stimulus-Control Testing*

During stimulus-control testing, 72 probe trials were added to the 288 trials of intermittent reinforcement. Every fifth trial of the session was a probe trial. On probe trials, one of three line tilts (22.5°, 45°, or 67.5°) was presented along with a red or green background on the center key. A response on the center key resulted in illumination of the side keys with the same probe line tilt and appropriate color backgrounds. Following a response on a side key, all keylights were turned off and a 15-sec intertrial interval began with illumination of the houselight. Reinforcement was not available on probe trials.

The 72 probe trials consisted of 24 presentations of each of the three line tilts. Each probe line tilt was tested six times on each of

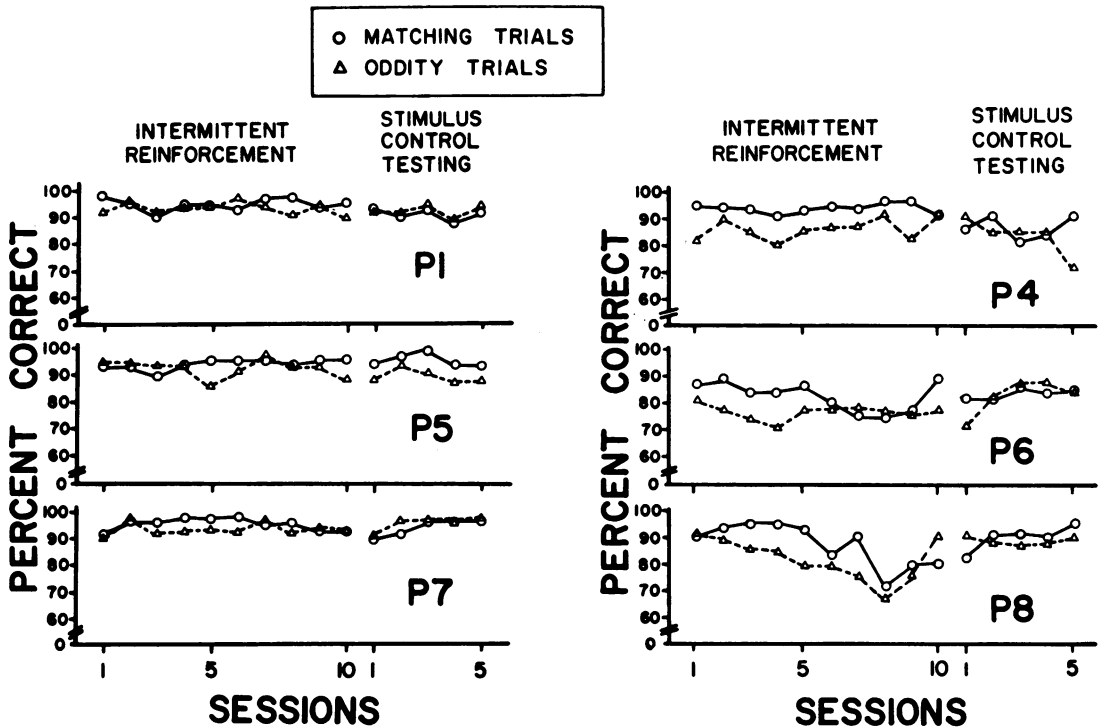


Fig. 1. Per cent correct on matching and oddity trials for each bird during sessions of intermittent reinforcement and stimulus-control testing.

the four different stimulus configurations of two colors. For each probe line tilt, the proportion of responding to the matching color or nonmatching color was determined. Stimulus-control testing was conducted for five sessions.

## RESULTS

### *Intermittent Reinforcement*

The overall accuracy of performance during the 10 sessions of intermittent reinforcement and the five sessions of stimulus-control testing is presented in Figure 1. For Subjects P1, P5, and P7, very high and stable levels of accuracy were maintained on both matching and oddity trials during intermittent reinforcement and stimulus control testing. For P4, P6, and P8, the accuracy levels were somewhat lower and more variable. In addition, these birds tended to show somewhat higher accuracy on matching trials than on oddity trials in a number of sessions during intermittent reinforcement. However, during stimulus-control testing, there was little accuracy difference between matching and oddity trials (*i.e.*, less than

10%), except for P4 during Session 5 of testing.

Since P4, P6, and P8 had lower levels of accuracy and more sessions in which matching-oddity accuracy differences were greater than 10%, a detailed analysis of responding was undertaken. For P4 and P8, the accuracy difference could not be attributed to any one specific stimulus configuration, while for P6, the difference was primarily due to lower accuracy on one particular oddity stimulus configuration.

### *Stimulus-Control Testing*

Gradients of stimulus control for line orientation are presented in Figure 2. For Birds P1, P5, and P7, an orientation of 90° from horizontal was correlated with reinforcement for responding to the mismatching color, while 0° was correlated with reinforcement for responding to the matching color. This relationship was reversed for Birds P4, P6, and P8. In Figure 2, the dependent variable is the per cent choice of the comparison stimulus that is the same color as the sample stimulus (*i.e.*, matching). This variable is plotted as a func-

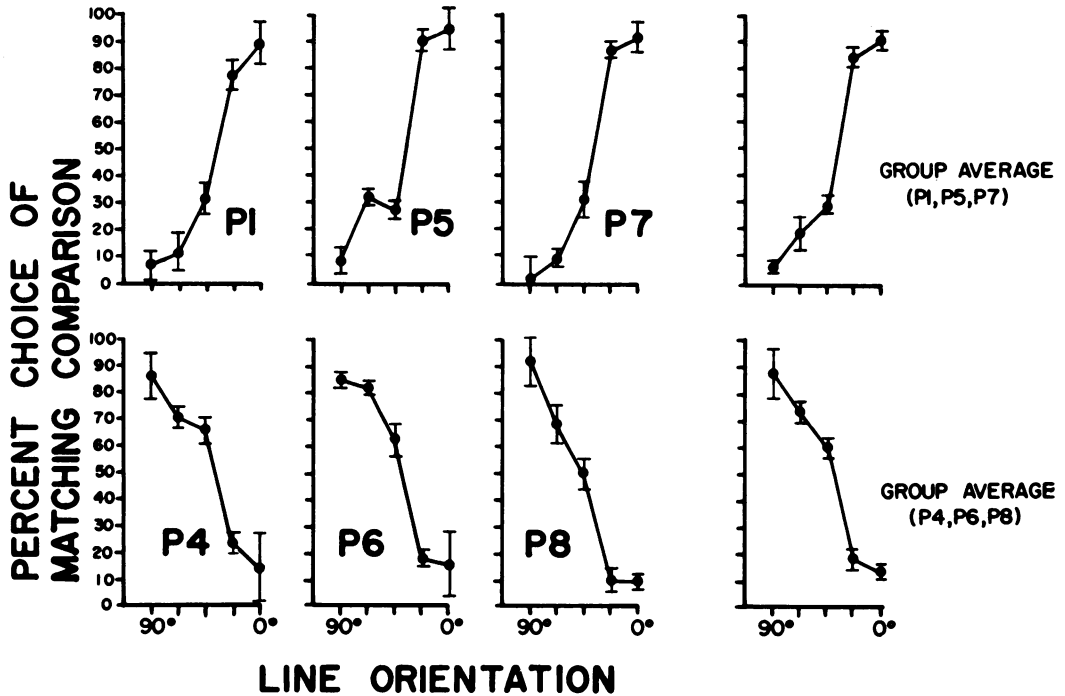


Fig. 2. Gradients of stimulus control for line orientation. The data points in the individual graphs represent means for the five sessions of stimulus-control testing. The vertical lines show the standard error of the mean.

tion of the angularity of the line presented on all three keys. For each bird, as the orientation correlated with reinforcement for matching responses on the color dimension was varied, there was a decreasing tendency to select the matching comparison. Only the gradient for P5 exhibited a slight departure from monotonicity. While these gradients were averaged over five testing sessions, they were representative of the individual gradients obtained for each test session. In addition, it should be noted that for both groups of birds, the greatest change in gradient slope was between the orientations of  $45^\circ$  and  $22.5^\circ$ , regardless of which orientation (*i.e.*,  $0^\circ$  or  $90^\circ$ ) was correlated with reinforcement for matching responses.

Since the gradients may have been affected by the development of position preferences when probe stimuli were presented, position bias to the left key in the presence of each probe stimulus was analyzed. Position preferences were very slight for all subjects, regardless of the nature of the probe stimuli. According to the Binomial Test ( $N = 120$ ,  $p = 0.5$  two-tailed), only two significant departures from no bias were found. P8 exhibited a mod-

erate right-key bias in the presence of the  $67.5^\circ$  probe, and P6 exhibited a moderate left-key bias in the presence of the  $22.5^\circ$  probe.

### DISCUSSION

The present data reveal that orderly gradients of stimulus control along the angularity dimension can be obtained by training pigeons under a higher-order conditional discrimination paradigm. These gradients fail to reveal a bias toward or away from the physically identical comparison stimulus. If such a bias existed, then the gradients of all birds should have revealed a similar bias in the presence of the  $45^\circ$  line. However, while those birds trained to oddity at  $90^\circ$  were more likely to select the odd side key when the line was  $45^\circ$ , the birds trained to match at  $90^\circ$  (except for P8) were more likely to select the matching side key when the line was  $45^\circ$ . The most parsimonious interpretation of these results is that the subjects in this experiment responded to a line tilt of  $45^\circ$  as if it were closer to  $90^\circ$  than to  $0^\circ$ .

In order to claim that a particular stimulus dimension controls behavior, one must clearly

show that changes in stimulus value along this dimension will result in changes in response probability (Honig, 1970; Terrace, 1966). Clearly, the present study demonstrated that line orientation controlled the tendency to select the matching or nonmatching comparison stimulus. One might interpret the present results as supporting the suggestion that the pigeons' behavior was under stimulus control characterized by the following rule: if line orientation is  $0^\circ$  (or  $90^\circ$ ) select the matching comparison, but if line orientation is  $90^\circ$  (or  $0^\circ$ ) select the nonmatching comparison. However, stating the nature of the stimulus-control rule in this fashion is clearly misleading if it is taken to imply that line orientation developed control over a generalized concept, such as matching or oddity. A previous study (Santi, 1976), found that line orientation did not initially control appropriate responding when blue and yellow were substituted for red and green. That is, performance dropped to chance levels. If line orientation were a discriminative stimulus for generalized matching and oddity responses, then blue and yellow should have been responded to appropriately from the beginning of transfer. It would appear that within the present paradigm, pigeons learned either a discrimination for each specific stimulus configuration or a set of specific stimulus-response chains based on compound stimuli in which the physical identity of sample and correct comparison stimulus played no special role. This conclusion is similar to that reached by Carter and Eckerman (1975) and Cohen *et al.* (1976).

However, some data remain that could be used to support the contention that physical identity of the sample and correct comparison stimulus has a special role in matching-to-sample paradigms. These data derive from studies by Berryman, Cumming, Nevin, and Jarvik (1964) and Nevin and Liebold (1966). Both of these studies demonstrated that with increased doses of sodium pentobarbital, matching accuracy was reduced to a greater extent than oddity accuracy. At present, these results cannot be accounted for. However, it would be worthwhile to examine the effects of sodium pentobarbital on the discriminative behavior established by the procedure employed in the present research.

While the experimental paradigm employed here was developed primarily to examine the

role of physical identity of the sample and correct comparison stimulus in matching-to-sample paradigms, it does bear a relationship to studies that attempt to teach animals to use instructional stimuli. The distinction between dimensional and instructional stimulus control has been made by Goldiamond and Dyrud (1968). While the former refers to control by a stimulus dimension over behavior, the latter refers to environmental control over which dimension controls behavior. From the experimenter's viewpoint, all studies in this sphere involve conditional discriminations. For example, pigeons could be taught to peck or not to peck at different key colors, depending on the presence or absence of a vertical line or tone. The exact procedures vary from study to study, but in all of the research reported thus far, the "instructional" stimulus involves the control of a simple discrimination (Boneau and Honig, 1964; Born, Snow, and Herbert, 1969; Heineman, Chase, and Mandell, 1968; Yarczower, 1971; Wilkie, 1973). The present research differs from these in that, at the procedural level, the instructional stimulus involved control of a conditional discrimination.

Research involving the use of instructional stimuli has attracted two well-deserved criticisms. The first concerns the distinction between dimensional control and instructional control. Gilbert (1969) argued that both forms of control are interrelated and that the kind of control that a dimension exhibits may depend only on the role of that dimension in the experimenter's definition of the situation. Because of this, there has been a tendency to use terms such as "stimulus control over stimulus control" (Gilbert, 1969) or "multi-dimensional control" (Wilkie, 1973), as opposed to instructional stimulus control. The second criticism relates to whether instructional stimulus control has been empirically demonstrated. Riley and Leith (1976) suggested that animals may merely be learning a number of simple habits to different compound cues in these paradigms. The data generated by the present discrimination procedure were also interpreted as indicating that the birds had learned simple responses to compound stimuli. Whether there are experimental procedures that would result in the kind of complex form of stimulus control that could be unambiguously interpreted as "instructional" is an open empirical question.

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